

Presentation for the Space Conference to be held at California State University, Long Beach, California on Saturday, September 22, 1990

## Atmosphere and Water Quality Monitoring on Space Station Freedom

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### ABSTRACT

In Space Station Freedom, air and water will be supplied in closed loop systems. The monitoring of air and water qualities will ensure the crew health for the long mission duration. Air and water quality monitoring are part of the Environmental Control and Life Support System (ECLSS).

The Atmosphere Composition Monitor (ACM) consists of the following major instruments: a single focusing mass spectrometer to monitor major air constituents and control the oxygen/nitrogen replenishment for the Space Station; a gas chromatograph/mass spectrometer to detect trace contaminants; a non-dispersive infrared spectrometer to determine carbon monoxide concentration; and a laser particle counter for measuring particulates in the air.

The Water Quality Monitor samples potable and hygiene water supplies and monitors 38 water quality parameters. It consists of the following major instruments: a high performance liquid chromatograph/ion chromatograph system to quantitate inorganics and carboxylic acids; a gas chromatograph/mass spectrometer to quantitate volatile organics; a UV/VIS spectrometer to measure color, turbidity, and iodine; a bacteria module to detect bacteria growth; and several sensor assemblies to measure mercury, total organic carbon, Ph, conductivity, and dissolved and entrained gases.

The air and water quality monitors will occupy approximately one and <sup>one</sup> half single equipment racks. They are being designed for automated operation with minimal crew involvement. This presentation will provide an overview of the design and development concepts for both monitors.

(NASA-CP-186707) ATMOSPHERE AND WATER  
QUALITY MONITORING ON SPACE STATION FREEDOM  
(Perkin-Elmer Corp.) 22 p CSCL 06K

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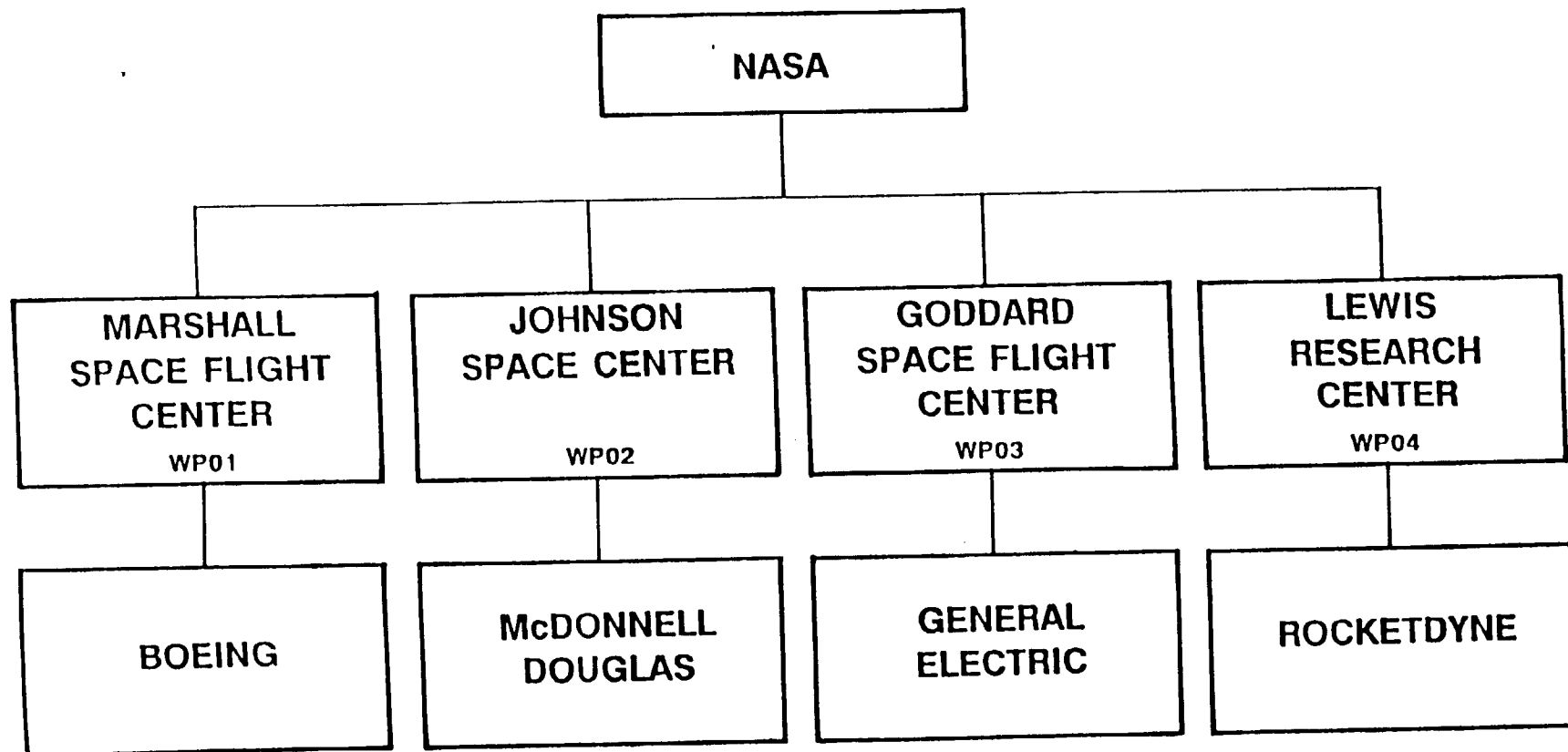
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ATMOSPHERE AND WATER QUALITY MONITORING  
ON SPACE STATION FREEDOM

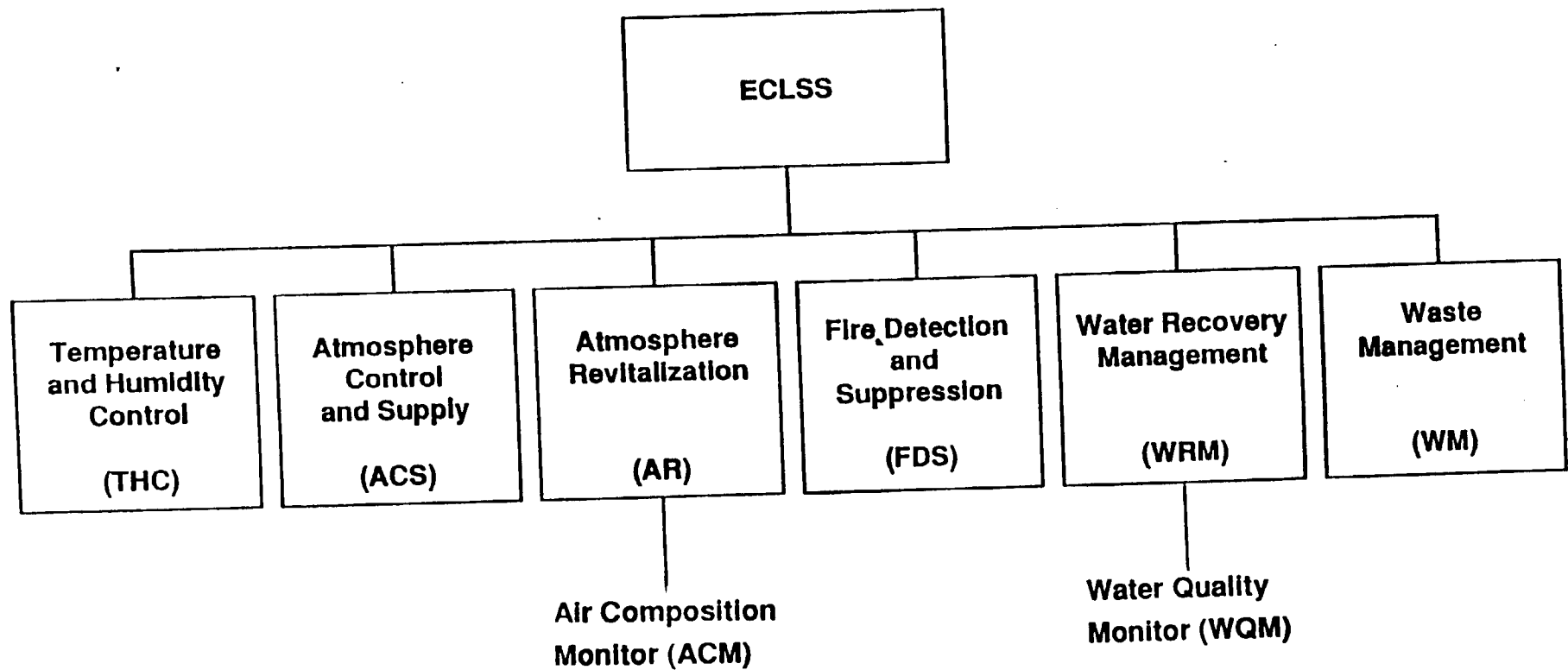
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## SPACE STATION PROGRAM



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## **ECLSS FUNCTIONAL GROUPS**



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- **MAJOR CONSTITUENT ANALYZER (MCA)**  
**MEASURES NITROGEN, OXYGEN, CARBON DIOXIDE,  
HYDROGEN, METHANE, AND WATER VAPOR**
- **CARBON MONOXIDE ANALYZER (COA)**  
**MEASURES THE CARBON MONOXIDE CONCENTRATION  
AT THE PPM LEVEL**
- **TRACE ORGANIC CONTAMINANT MONITOR (TCM)**  
**MEASURES TRACE ORGANIC  
CONTAMINANTS AT THE PPM LEVEL**
- **PARTICLE COUNTER MONITOR (PCM)**  
**MEASURES COMPLIANCE WITH THE  
CLASS 100,000 CLEAN ROOM SPECIFICATION**

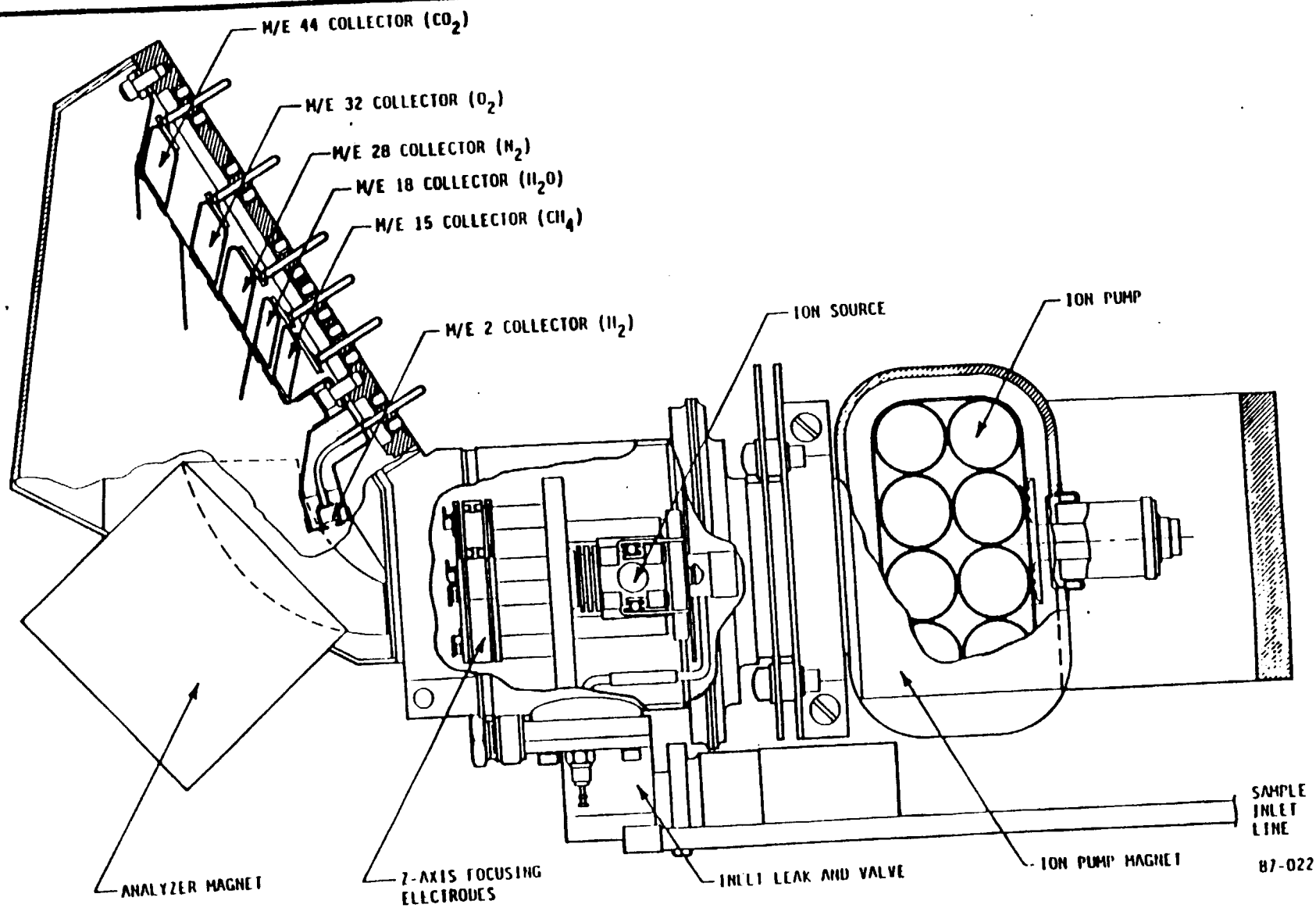
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**ACM INSTRUMENT OVERVIEW**

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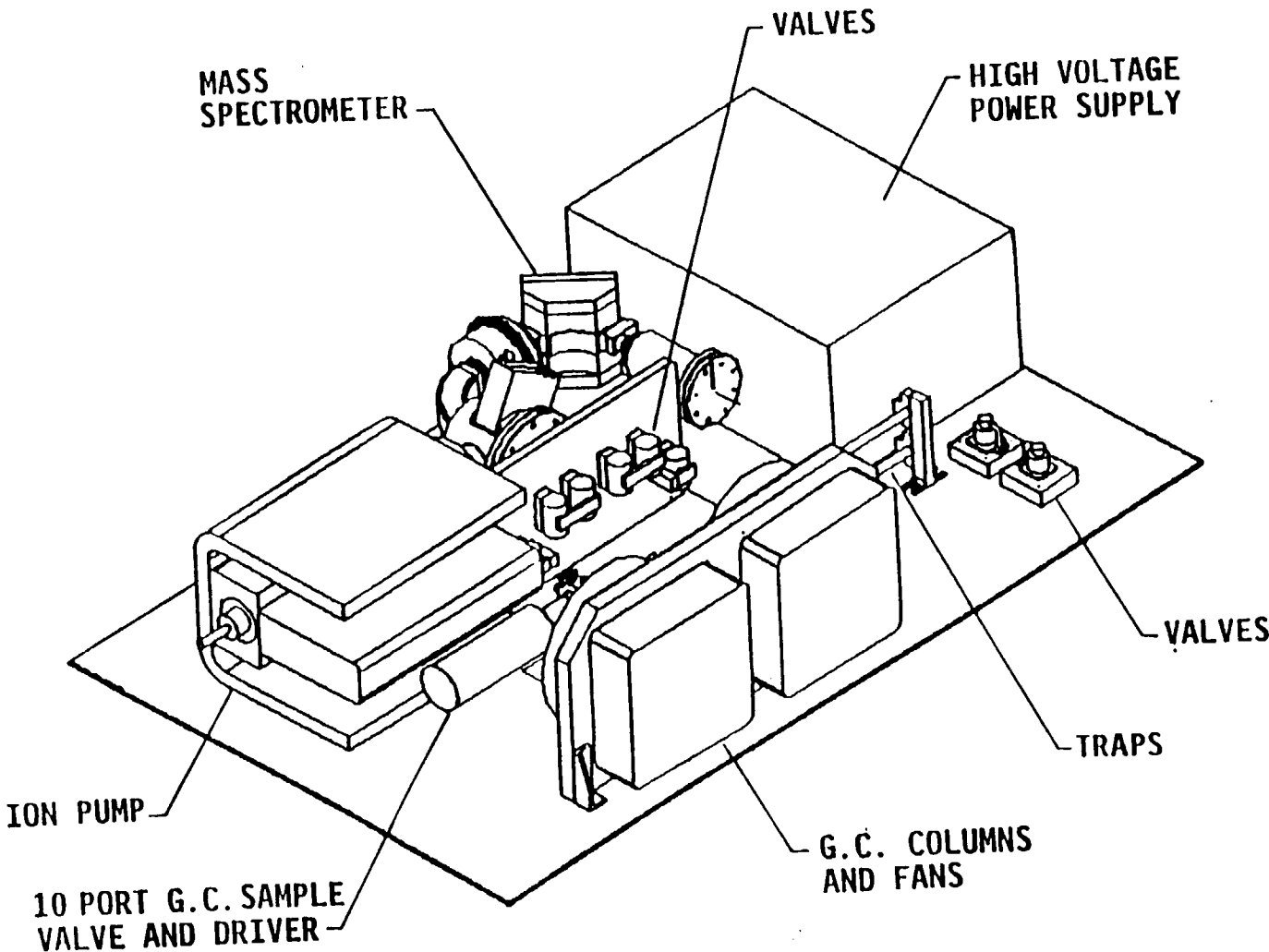
- **MCA - DERIVED FROM SKYLAB METABOLIC ANALYZER AND SPACE LAB GAS ANALYZER MASS SPECTROMETER**
- **TCM - DERIVED FROM VIKING LANDER GC/MS AND SPACELAB TRACE GAS ANALYZER**
- **COA - DERIVED FROM NAVY SUBMARINE COA**
- **PCM - DERIVED FROM TSI, INC. MODEL 3755 LASER PARTICLE COUNTER**

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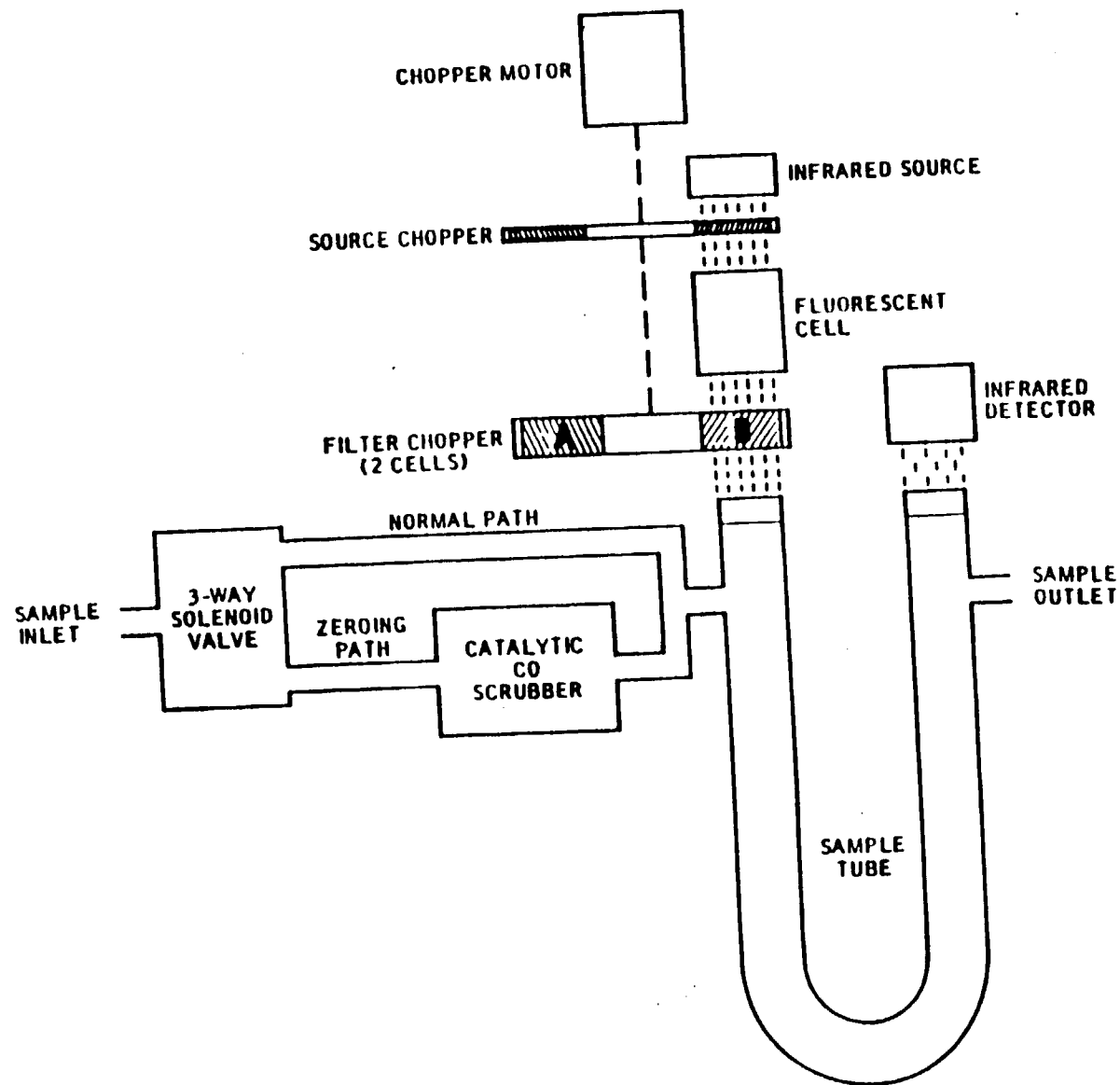
# TRACE CONTAMINANT MONITOR



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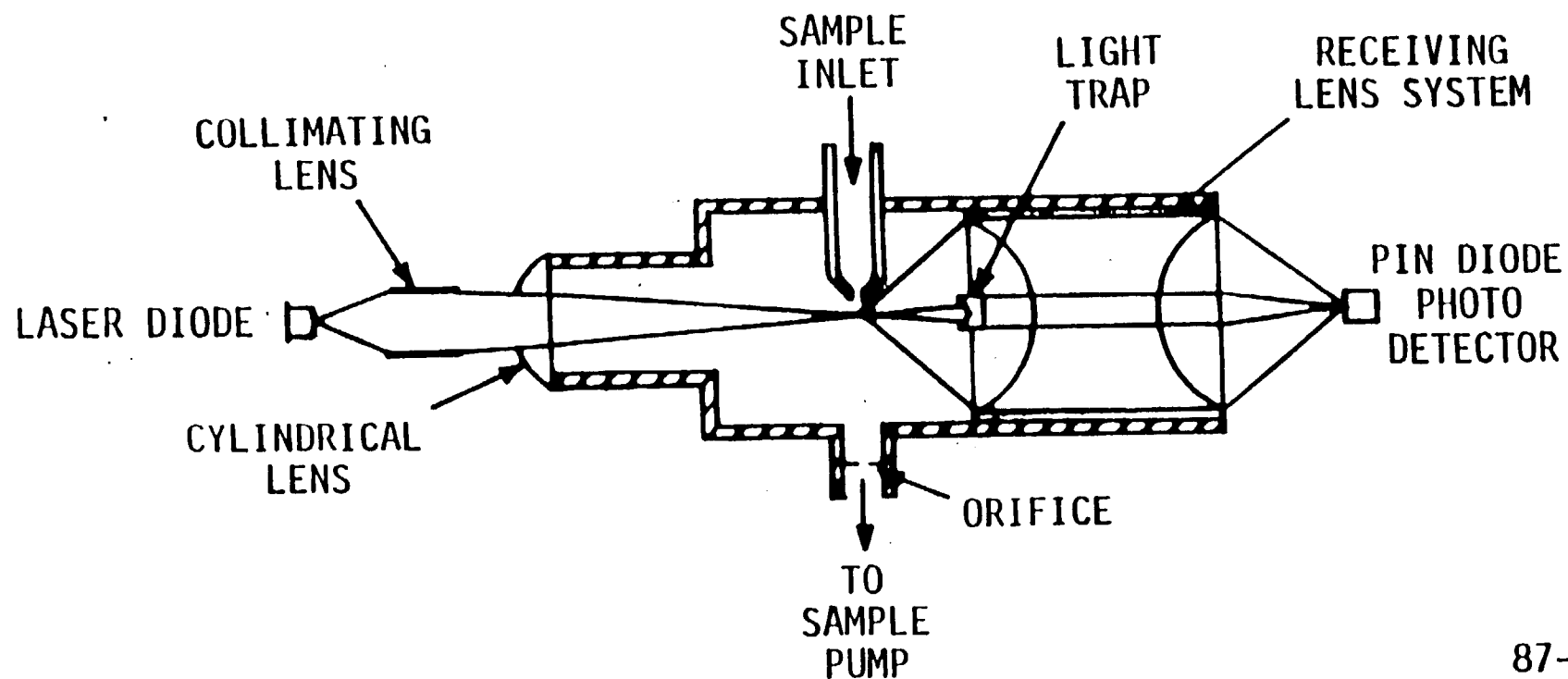


# CARBON MONOXIDE ANALYZER SAMPLE PATH AND INFRARED OPTICS



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# PARTICLE COUNTER MONITOR SCHEMATIC DIAGRAM

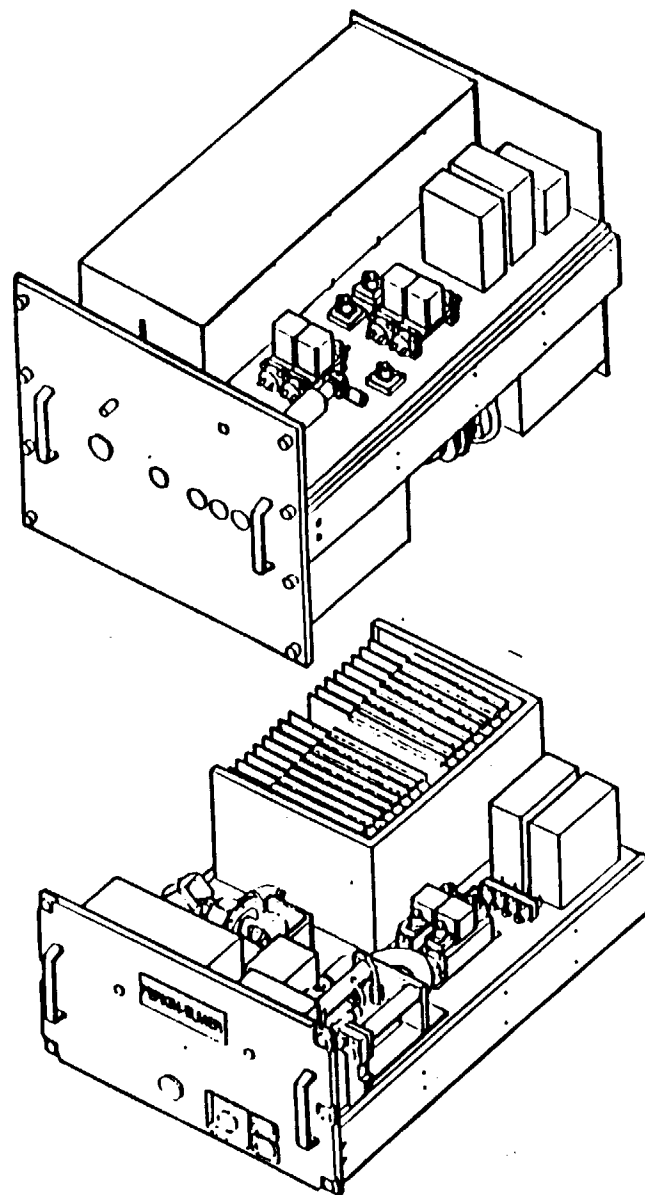


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# ACM SYSTEM

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**WQM**

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**WQM FUNCTIONAL OVERVIEW**

**SAMPLE POTABLE & HYGIENE WATER SUPPLIES**

**DETERMINE 38 WATER QUALITY PARAMETERS**

**RESULTS ASSURE WATER QUALITY**

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## **WQM CHALLENGES**

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- **MICROGRAVITY COMPATIBILITY**
- **AUTOMATION**
- **INSTRUMENT SELECTION**
- **POWER AND WEIGHT**
- **SAMPLING SYSTEM**
- **RELIABILITY AND MAINTAINABILITY**

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**TRADE-OFF CRITERIA**

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- **FUNCTIONALITY**
- **MICROGRAVITY COMPATIBILITY**
- **POWER, WEIGHT, COST**
- **ENVIRONMENTAL COMPATIBILITY**
- **SAFETY, RELIABILITY, MAINTAINABILITY**
- **CONSUMABLES, WASTE DISPOSAL**
- **LOGISTICS, RESUPPLIES**
- **MATURITY, RISK**
- **COMMONALITY**

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## WQM INSTRUMENT SELECTION MATRIX 1

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<u>PHYSICAL PARAMETER</u>	<u>RFP LIMITS</u>	<u>TECHNIQUE</u>
pH	6<pH<8 5<pH<8	POTABLE COMBINATION ELECTRODE HYGIENE
CONDUCTIVITY	0 - 1000 $\mu$ S/cm	CONDUCTIVITY CELL
COLOR	15 PT/CO	UV-VISIBLE SPECTROSCOPY
TURBIDITY	1 NTU	UV-VISIBLE SPECTROSCOPY
DISSOLVED GAS	0.10 mL/L	GAS CHROMATOGRAPHY/- MASS SPECTROSCOPY
FREE GAS	0.10 mL/L	PHOTOMETRIC

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## WQM INSTRUMENT SELECTION MATRIX 2

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<u>PARAMETER</u>	<u>RFP LIMITS</u>	<u>TECHNIQUE</u>
<b>INORGANIC CATIONS</b>		
AMMONIUM (NH <sub>4</sub> <sup>+</sup> )	0.50mG/L	HIGH PERFORMANCE LIQUID CHROMATOGRAPHY " " " " " " " " " "
BARIUM (Ba <sup>2+</sup> )	1.00 "	
CADMIUM (Cd <sup>2+</sup> )	0.005"	
CALCIUM (Ca <sup>2+</sup> )	30.0 "	
COPPER (Cu <sup>2+</sup> )	1.00 "	
IRON (Fe <sup>3+</sup> )	0.30 "	
LEAD (Pb <sup>2+</sup> )	0.05 "	
MANGANESE (Mn <sup>2+</sup> )	0.05 "	
MAGNESIUM (Mg <sup>2+</sup> )	50.0 "	
NICKEL (Ni <sup>2+</sup> )	0.05 "	
POTASSIUM (K <sup>+</sup> )	340 "	
SILVER (Ag <sup>+</sup> )	0.05 "	
MERCURY (Hg)	0.002"	GOLD FILM ANALYZER

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## WQM INSTRUMENT SELECTION MATRIX 3

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<u>PARAMETER</u>	<u>RFP LIMITS</u>	<u>TECHNIQUE</u>
<b>INORGANIC ANIONS</b>		
ARSENIC ( $\text{AsO}_4^{3-}$ )	0.01mG/L	HIGH PERFORMANCE LIQUID CHROMATOGRAPHY
CHLORIDE ( $\text{Cl}^-$ )	200 "	
CHROMIUM ( $\text{CrO}_4^{2-}$ )	0.05 "	
CYANIDE ( $\text{CN}^-$ )	0.20 "	
FLUORIDE ( $\text{F}^-$ )	1.00 "	
IODIDE ( $\text{I}^-$ )	15.0 "	
NITRATE ( $\text{NO}_3^-$ )	10.0 "	
SELENIUM ( $\text{SeO}_4^{3-}$ )	0.01 "	
SULFATE ( $\text{SO}_4^{2-}$ )	250 "	
SULFIDE ( $\text{S}^{2-}$ )	0.05 "	

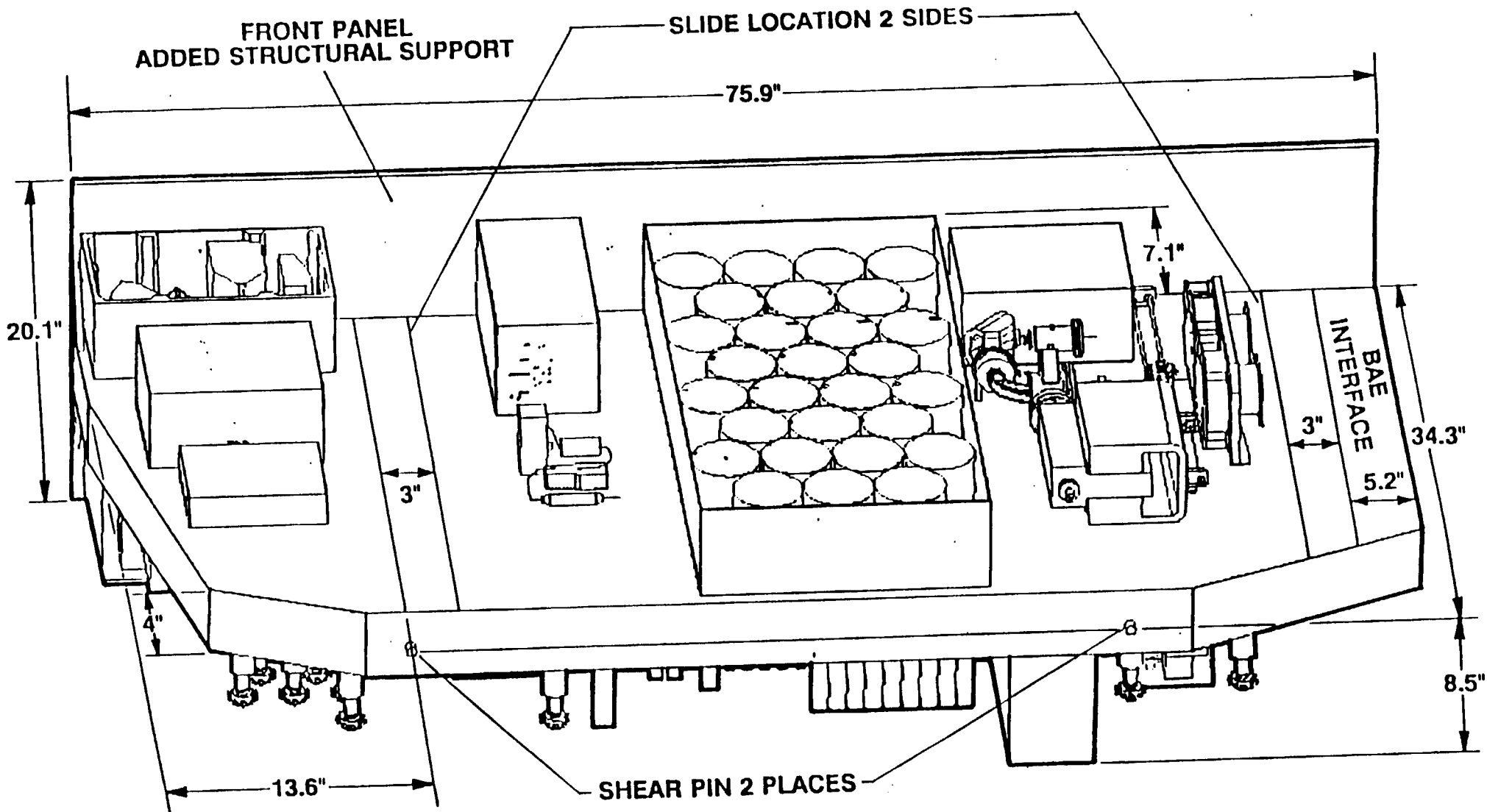
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## WQM INSTRUMENT SELECTION MATRIX 4

PARAMETER	RFP LIMITS	TECHNIQUE
<b>ORGANICS</b>		
TOTAL ORGANIC CARBON(TOC)	0.50 mg/L POTABLE 10.0 " HYGIENE	UV OXIDATION
<b>SPECIFIC ORGANIC TOXICANTS</b>		
ALCOHOLS		
ALIPHATIC	500 µg/L	GC/MS
PHENOLS	1.0 "	GC/MS
HALOGENATED HYDROCRBNS	10 "	GC/MS
ORGANIC ACIDS	100 " POTABLE 500 " HYGIENE	GC/MS, HPLC "
<b>BACTERICIDE</b>		
IODINE (I <sub>2</sub> )	0.5 < [I <sub>2</sub> ] < 4mg/L POTABLE 0.5 < [I <sub>2</sub> ] < 6 " HYGIENE	UV-VISIBLE SPECTROSCOPY
<b>BACTERIA</b>		
TOTAL COUNT	1 CFU/100ML	CONDUCTIVITY UV-VISIBLE SPECTROSCOPY

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# WQM VERTICAL DRAWER OVERALL DIMENSIONS



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OK per D. J. M. Carley 7/31/90

## Narrative for the Presentation on "Atmosphere and Water Quality Monitoring on Space Station Freedom."

### 1. **ATMOSPHERE AND WATER QUALITY MONITORING ON SPACE STATION FREEDOM**

This presentation is intended to provide an overview of the development of an atmosphere composition monitor and a water quality monitor for the Space Station Freedom.

These two monitors are currently in development by the Perkin Elmer Corporation, Applied Science Division under the contract of Boeing Aerospace and Electronics.

### 2. **SPACE STATION PROGRAM**

This viewgraph gives an overview of NASA's Space Station program. The program is divided into four work packages with four prime contractors as shown.

### 3. **ECLSS FUNCTIONAL GROUPS**

One of the major functions in Work Package 01 is the development of the Environmental Control and Life Support System (ECLSS). The ECLSS is divided into six functional groups as shown.

The air and water supplies for the Space Station are closed systems. Their qualities must be carefully monitored to ensure crew health. The Air Composition Monitor is part of the Atmosphere Revitalization subsystem and the Water Quality Monitor is part of the Water Recovery Management subsystem.

### 4. **ATMOSPHERE COMPOSITION MONITOR FUNCTION**

The Atmosphere Composition Monitor consists of four instruments and their main functions are shown in the viewgraph.

### 5. **ACM INSTRUMENT OVERVIEW**

All the instruments selected for the ACM are mature design. They are derived from different programs as shown in the viewgraph. The ACM program is to consolidate these instruments, upgrade the electronics, package them into two drawers, and develop software to provide continuous analysis.

## **10. ACM SYSTEM**

These four instruments are packaged into two drawers as shown. The TCM and the PCM are packaged into one drawer and the MCA and the COA are in one. The two drawers fit in about half of a single rack and weigh about 300 pounds.

## **11. WQM**

In Space Station Freedom, the water supply will be a closed loop system. Humidity condensate from the cabin and waste hygiene water including urine are to be reclaimed for potable and hygiene uses. Close monitoring of the water quality is mandatory to ensure crew health.

The Water Quality Monitor will sample potable and hygiene water to determine 38 water quality parameters.

## **12. WQM CHALLENGES**

Water quality monitoring is an EPA requirement and is commonly done in earth laboratories. However, to monitor water quality in space will be quite different. EPA standard methods cannot be applied in space directly because of their gravity dependency, sample requirements, and sample handling procedure. In addition, power, weight, reliability, and maintainability requirements are less important on earth laboratories.

## **13. TRADE-OFF CRITERIA**

Unlike the instruments in the atmosphere composition monitor which are derived from mature design, the water quality monitor has never been flown in space before. To ensure the proper selection of instruments, we have conducted an extensive trade-off studies and analytical testing to reach our instrument selection. The trade-off criteria are shown in this viewgraph.

## **14-17. WQM INSTRUMENT SELECTION MATRIX**

The water quality specification and the selected instruments are shown in the next four viewgraphs. Due to the time constraint and the complexity of the system, only a few major instruments will be discussed.

As shown in the viewgraph, the high performance liquid chromatograph/ion chromatograph has been selected for analyzing most of the inorganics. Ion chromatograph is a separation technique based on ion exchange principle. A sample is usually introduced through a sample injection valve and carried to a separation column by a high pressure pump. The separation is based on the

affinity of chemical species to functional groups located on the ion exchange column. A conductivity cell is usually used as detector.

Another widely used instrument in the water quality monitor is the UV/VIS spectrometer. The spectrometer can be used to measure iodine, turbidity, color, and serve as detector for high performance liquid chromatograph.

The GC/MS is one of the popular EPA methods for measuring volatile organics. The same type of GC/MS used in the ACM will be used for water analysis. The standard EPA GC/MS sampling involves the use of a "purge and trap" method which uses gas to bubble through the water sample to carry the volatile organics from water into gas phase. However, the "purge" will not function in space, a gravity independent volatile organic concentrator has been developed for this application.

For bacteria detection, we selected a combination of filter/incubation/ conductivity method to detect bacteria growth.

There are several other sensors/analyzers for measuring the remaining parameters on the list.

#### **18. WQM VERTICAL DRAWER OVERALL DIMENSIONS**

All the instruments/sensors will be packaged into one large drawer occupying a single rack. The reason for this vertical drawer packaging concept is to minimize the inter-connect plumbing. The overall weight of this water quality monitor is about 500 pounds.